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FRANCE: NUCLEAR, MISSILE, AND SPACE DEVELOPMENTS  
FOUO No. 458

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RESULTS, WEAKNESSES OF NATION'S NUCLEAR PROGRAM VIEWED

Paris L'EXPANSION in French Feb 79 pp 104-107, 109, 111

[Article by Michel Herblay: "The Everyday Atom"]

[Text] Reader, my friend, you who are going through this issue of L'EXPANSION, you get your lighting 1 day out of 6 from electricity of nuclear origin. If you were a citizen of Federal Germany, it would be one day out of nine, if British, one day out of eight, and, if Belgian, one day out of four. Nuclear energy has invaded our daily life softly, in spite of the protests and the hue and cry of the "opposition." Simply at the present, still modest, rate, the atom represents for France a saving of 8.5 million tons of oil per year. That is not much? It is close to 1 billion dollars.

On the world scale, about 600 Terawatt-hours (billions of Kilowatt hours) of nuclear electricity were produced in 1978: without them, it would have been necessary to extract 132 additional million tons of oil--half the Iranian production or 200 million tons of coal. Last summer 228 reactors were humming throughout the world, or rather in the 22 countries sufficiently industrialized to have them. With incidents, but no accidents. As many building yards were open, heavy machinery whose completion takes 6 to 8 years, each requiring half a billion to 1 billion dollars investments. "Nuclear" energy is no longer a working hypothesis, a dream of the technicians, approved or opposed, but an industrial data already of long standing. That is what caused the sociologist Alain Touraine to say, at the recent 'National As-sizes against Nuclear Energy,' that the opposition movement incurred the risk of "weakening with the launching of the first PWR [pressurized-water reactor] power stations (the French line being implemented), of becoming exhausted towards 1981, and disappearing."

Is it too early to attempt a first technical, industrial, economic and human evaluation? The Professionals, who are always prudent, until cruising conditions are reached, would no doubt prefer to meet after 10 years, when the stages of prototypes, the units preceding mass production and the first of the mass produced units are only subjects of history. "It took a long time to accomplish", said Remy Carle, EDF head of thermal (hence, increasingly nuclear)

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production. "But this very slowness, both intentional and inflicted, was beneficial: in this age, we have no right to permit a failure in a decisive technological mutation."

"It works"

To fail in a mutation...The first cargo boat carrying liquid methane exploded in an American port, causing hundreds of victims, and for 20 years, no one dared to return to planning such a "floating bomb" project. Today, oil tankers operate without any incident, but up to today, the project of setting up a nuclear unit in the Fos area has been blocked by this argument: and what if a tanker, calling at the Fos terminal, were to explode, how would the power station resist? The latter cannot explode physically, but no one is unaware of the fact that the nuclear reaction is not a harmless phenomenon. Hiroshima will be an eternal reminder.

It took a long time, but "it works." Almost better than the first 250 megawatt coal and fuel units, at the beginning of the 60's. Remy Carle who is operating this equipment, designed and manufactured by others, plots "availability curves" which, it seems, are envied by the Americans. In cruising conditions, a standardized and "adult" (more than three years old) piece of equipment would be able to operate at 85 percent full power, the remaining 15 being devoted to the need of refueling and current maintenance. Before this fourth year, the power station is supposed to have paid the price for the running in and the "childhood diseases," a price which is higher in the case of pre-series or the first unit of the standard production. The PEON [Production of Energy of Nuclear Origin] Commission first assumed a 34 percent availability during the first year of operation of a unit at the 900-megawatt level, a rate it then increased to 50 percent, i.e., 4,260 hours.

Now, it was observed that:

--The Westinghouse reference unit (Beaver Valley), from which Framatome derives its licence, had not reached 3,000 hours;

--Fessenheim I crossed correctly the 50 percent level;

--Tihange (Franco-Belgian) and Fessenheim II crossed it with three months to spare;

--None of the first classical thermal units of the 250 and 600-megawatt level had attained a 50 percent availability; only the first 700-megawatt fuel unit, at Cordemais, had been able to compete with Fessenheim I, but is nonetheless beaten by Tihange and Fessenheim II.

From the technical point of view, the French have been successful, and this is readily agreed to in the international seminars. Is that an accident? If not, how could it be explained?

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Three nuclear units do not represent reliable statistical data, and both at EDF [French Electric (Power) Company] and Framatome, they "are touching wood." The role played by chance will only be confirmed by 1981, when the four Tricastin units are operating (they represent the real standard industrial series). "We profited by a privilege of which we are fully aware," the people at Framatome admit, "The Americans are the ones who bore the brunt."

This tribute, materialized into a fee paid to Westinghouse ("not much for the service rendered," Framatome specified: 5 percent of the cost of the reactor, less than 2 percent of the cost of the power station) is one willingly paid by EDF. General Electric and Westinghouse have paid for their apprenticeship by tremendous losses, exceeding 1 billion dollars. The great German company AEG [Allgemeine Elektrizitaets Gesellschaft] was almost destroyed and had finally to give up nuclear energy. This is therefore the first--considerable--advantage, and one which was not contradicted by the experience previously acquired in France with the graphite-gas line: the practical and economical aspects of a prototype and a standard equipment cannot be compared.

The second chance factor, not observed anywhere else, is the EDF strategy for standardizing the orders. This is an old story, relating to the unpleasant memory of the implementation of the 250-megawatt coal and fuel level. The first 8 units of this series, coupled from 1961 to 1965, had an availability of only 22 percent during the first year of operation. They were ordered, one unit at a time, often from different sources, often from rival suppliers. In short, they were never identical, and their operation meant coping with eight types of running in and childhood diseases. There was a slight improvement for the next 20 units, with an availability of 37 percent during the period 1966-1970. Thereafter, the principle of ordering series of identical equipment, from the boilers to the chimneys, gave a spectacular result for the last eight units of this group: the average rate of availability reached 90 percent.

Rapid Implementation

Units of 250 megawatts are no longer being manufactured, but the industrial policy was retained, and the 2,000 companies manufacturing nuclear equipment, the thousands of persons "converted" or trained for their operation and maintenance know that they will not have to learn their job again at each EDF order. The advantage of repetition is symbolized by the discount offered by the supplier by adhering to the program, and by the penalty incurred by the client if he is forced to modify the volume or the schedule of the line ordered; it consists in a quality of the equipment which is easier to reproduce since it is standardized, and especially a faster implementation. Now, a week, a month, a year saved in the slow process of standardizing the nuclear tool, represent billions of kilowatt hours which the country will not be lacking, billions of francs which will not be unproductive. What is more foolish than having a non-available power station?

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The principle of the identical units for a given power level (which was always championed stubbornly by Michel Hug, Equipment Director at EDF) had nevertheless certain complex effects, which occasionally aroused criticisms.

In view of the dimensions of the French energy market, standardizing led to the designation of a single supplier applying a single technique. These suppliers included Framatome for the reactors, Altshom-Atlantique for turbo-alternators, the Westinghouse licence for the PWR model. After many discussions and hesitations, the idea of resorting to other techniques and other constructors was given up. Remy Carle, who had worked for a long time at the Atomic Energy Commission before becoming Michel Hug's colleague, admits that he is one of the persons who regret the absence of a second supplier. He specifies that this regret is 'purely sentimental', for he is not unaware of the fact that neither of them would have reached the threshold of equilibrium, and that the operator--he, Remy Carle--would have to overcome not one but two worlds of difficulties.

Technological Rigidity

Framatome rejoices that it was chosen, but is not yet triumphant. This branch of Creusot-Loire inherited the nuclear personnel formerly employed by its rivals: 42 engineers and technicians come from Babcock, 200 from GCE [expansion unknown], a valuable contribution in an area in which the quality of the teams is of primordial importance. The regularity of the EDF orders makes it save time and win over people, but this EDF series (5000 to 6000 megawatts per year) is not sufficient to keep its production means employed on a full time basis. Every year 2,000 to 3,000 megawatts more are needed. The coherent EDF program represents a basis, a reference; the identical units furnish the guarantee for an easier maintenance, but Jean-Claude Leny, Director of Framatome, is surveying the world rather than the French nuclear provinces. If he is unable to install under foreign skies two Fessenheim units every year, the industrial line will not fulfill its promises, for want of the right amortissement of the production means set up to satisfy the EDF needs.

The criticism most often levied against identical units is the technological rigidity it induces. In this area of activity which is still young, advances are achieved every year in the research centers, in the architecture of the power stations, in the organization of the construction yards, in the design of the equipment, and the Administrator (with a capital A which annoys the technician) is opposed to their adoption. The second in line could be better than the first, the third, better than the second. But since the line has purposely been fixed, this will never be. Is that a scandal?

It is obviously one in the eyes of the technicians, who love a "beautiful machine." As for Michel Hug and Remy Carle whose eyes are directed at the availability curve of their fleet of power stations, this rigidity represents an insurance against hazards. They accept only two types of modification for the line: those imposed on them by the safety regulations, and those resulting from the experience acquired on the prototypes, and the units of



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prestandardization or the first units in the line. As regards the rest, the "improvements" will wait for the next line, or the next level, to be applied all together.

A nuclear power station is a system, materializing in the shape of components. There was no precedent for the nuclear system; it required a mass of new data, in rapid evolution, and as they say at Framatome "one had to be able to assimilate." Although France had not the means available in America, it was not without means, as would later be the case for the young countries which would seek to equip themselves with electronuclear equipment: a long research tradition symbolized by the Curie family, the creation of the Atomic Energy Commission and its development under the pressure of military ambition in the fifties, the experience acquired with the graphite-gas reactors, the sounding of other lines (heavy water at Brennilis, light water at Chooz) had made the men familiar with the needs of the nuclear system, of the nuclear quality. They could not however assimilate straight off the system with light water and enriched uranium--60 percent of the world's systems--which the Americans were championing. Hence the recourse to the foreign licence and helping hand, which by a mischievous paradox, became relatively more efficient in France than in the United States.

As a matter of fact, the requirements of the system-component pair, come up, on the other side of the Atlantic, against specialization of the enterprises. Westinghouse is specialized in electricity, not in boiler making; for Babcock, it is just the opposite. Westinghouse has always ordered its reactor tanks from abroad (including from Framatome, even before the EDF had adopted the PWR. In a Westinghouse power station, the weak point is often the steam generator, or the taps, for which the American company ended up by building a factory itself, failing to find satisfaction with the subcontractors.

It was then that the defects of the modest dimensions of the French industry proved to be useful. In the case of an activity in which the cohesion of the system and its components is decisive, the very French fact that the men "know each other" in spite of their belonging to different organizations is emphasized by everybody as a great asset. AEC [Atomic Energy Commission], EDF, Le Creusot, Framatome, Jeumont-Schneider, Alsthom-CEM constitute a small world coming from the same schools, launched into the same technical adventure and accustomed to making do with the available means. A French nuclear workshop is like the cross-roads where one meets everybody. "There is a phenomenon of congregation," says a Framatome official. Intolerable in other areas in which specialization represents a pledge of productivity and the "company spirit" is a competitive virtue, this collusion permits French industry to build a nuclear unit in 6 years, whereas Westinghouse takes 8, and to have greater success with Fessenheim than its licensor had with Beaver Valley.

The Franco-Belgian Chooz prototype, a forebear on a reduced scale of the present EDF program, had had, when it first started, the worst troubles (stopping from 1968 to 1970) because the assembly screws of the collars of the internal structures did not hold firmly. The obsession for nuclear quality,

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which is very special, should imbue all those participating in the collective work. The Soviets, who are building an industrial town to locate all the means of manufacturing the components of a power station are coming round to this opinion.

Therefore, although as a whole the first really industrial steps of the electronuclear system in France appear to be fairly firm, indeed more assured than those of the large classical equipment 25 years ago there remain shadowy areas to be explored, shortages to be eliminated and failures to be corrected. All these may be measured in terms of non availability of the power station.

The most absurd, least nuclear, and even least electric incident was the 1976 drought which paralyzed many European units cooled by rivers whose flow had dropped. The most sophisticated mastery of nature, subjected to climatic whims, how absurd! Whether or not it was liked (because the cost of the additional investment is high), the open cycle fresh water cooling is banned in favor of aerocoolants and sites on the sea coast.

The problem which was most poorly solved concerns once again water, but this time, that used by the steam generators. It is impossible to produce a really pure industrial water, or one which stays pure: "It is difficult because it involves researchers in all the areas, chemists, physicists, mechanics, thermal specialists." An untimely breakdown is due to the water, to the incrustated deposits of metal oxides, to breaks in the seal of the secondary circuit (i.e., outside the nuclear core), the crushing of the pipes. Even then, the French assert that they suffer less from the effects of that wretched water than their American and Japanese colleagues, perhaps because the Westinghouse steam generators are particularly sensitive, whereas the old tradition of the Creusot boilermakers benefits the Framatome equipment.

Then all the troubles inherent in all rotating machines are encountered: turbine blades being deformed, elements heating up. Or all the equipment containing fluids: leaking taps, pumps wearing out. It is nothing, a mere triviality, but the operator protests. Stopping for one month (November 1977) the 900 megawatts of Fessenheim I to replace a pump of the water system is more provoking than the stopping of a 125- or 250-megawatt unit.

On the whole so much care was lavished on the nuclear unit, that the latter now causes less anxiety than the classical machinery manufactured for a long time, but which has to be enlarged to the dimensions and the economic stresses of the nuclear system. Just as in the United States, the acute problem of the taps will be solved sooner or later by the creation of a special factory where nuclear cocks and fittings will no longer be considered as "ducks in a chicken coop," but as the basic product, to which all efforts are devoted.

In the hierarchy of difficulties, the hardest problem to solve is not material. It is the matter of the "programmed stops," which the operator laments beforehand. Fessenheim I will stop for 4 months this spring, and Fessenheim II for 4 months starting in June: complete control, as per regulations, of

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the primary circuit (in the reactor), and normal discharge of one-third of the fuel. Then every year, each French program unit will shut down for 2 months to renew the fuel.

Remy Carle does not understand. He will not accept that repetitive operations, lasting 3-4 weeks in the United States or Germany, should extend to 8 weeks in France. By the end of its existence, the French power station incurs the risk of having worked 2 years less than its counterpart in the other industrialized countries.

The problem is not specific to the "Technical Production Department" of the EDF, nor to the after sales service of Framatome or Alsthom. It is an overall one. A national one. The French industrial fabric permitted a fairly brilliant entrance into the narrow circle of electronuclear powers, with the bonus of a complete mastery of the fuel cycle (enrichment at Tricastin, reprocessing at La Hague, vitrification of the wastes at Marcoule): it is not dense enough to supply permanently the forces which would assure the maximum "availability" of the system, which, at the beginning of 1986, will include 90 900-megawatt units and 11 of the 1300-megawatt level.

"We need men," they say at EDF rather anxiously, "Many more than we can recruit and train."

Framatome adds: "We spend our time pinching welders from each other."

And what is going to happen when the same French industrial fabric has to help for the operation and maintenance of the two plants which have to be exported every year? The case of the welders has become legendary. There is no lack of training schools and technical high schools in France, but nuclear qualifications have not yet become part of the public education system. The nuclear enterprises have set up their own schools; but as soon as they are trained, those with "nuclear qualifications" become the object of bitter disputes between the chemical and oil industries who also complain of a shortage of highly qualified welders.

Although welding is always the case cited, the personnel problem is a general one. The first Framatome deliveries had to be delayed for want of suitable personnel, and strikes have just come up in the first EDF 900-megawatt power stations, because the operating teams were not large enough. If the French company is incapable of producing in sufficient number persons with nuclear "mentality" and "skill," will it have to undergo the mortification of calling upon German, American, Japanese technicians to operate the power stations it is exporting, or to reduce by half the period of recharging of the stations set up on its own territory? "The operators of nuclear power stations are already meeting in international clubs, where they exchange their experiences," Remy Carle remarked. Should one go further still, and contemplate international service companies equipped to intervene, on a full time basis on the shut-down reactors?

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Everything Is Too New

There now remains for us to assess the--enormous--odds of the financial bet. The analysts seeking to know whether the nuclear energy "is profitable" for the enterprises which invested in it only receive evasive replies. Everything is too new, too young. Too many construction yards are still being set up, too few completed power stations have admitted their operating balances. Furthermore, the economic budget of the prototypes and prestandardized units mean nothing to the builders or the operators, a company truth of which the nuclear system does not hold any monopoly. With much simplification, it may be stated that:

1. Everybody has lost money up to now, knowing that that was the price that had to be paid to enter into this new industry. The first industrialists to receive a profitable price were the producers of uranium oxide in 1975-1976; this causes dramas, by the way, for the builders of power stations, who had engaged to furnish to their customers fuel at a fixed price and on a long term basis.

2. The operating results are and will be very different according to the level of development of the countries in which nuclear units are set up. To predict that the nuclear kilowatt hours will remain less costly than the kilowatt hours from coal or oil is only valid in the countries already highly industrialized, and who have decided to go in for nuclear equipment in "series." Although the fuel cost is international, the investment cost is double in under-industrialized countries, and the operating costs much greater.

3. The rapid evolution of the technology and safety regulations have long prevented the precise calculation of the costs of the installed kilowatt hours and the kilowatt hours generated. The financial managers were working on forecast calculations revised every year, and always on the rise. This whirlwind has been subsiding since 1977. The Fessenheim invoice, for example, passing (in steady Francs) from 1,155 francs per installed kilowatt hours in 1972 to 2,650 francs in 1977, leads to an estimate of 2,840 francs in 1978. In the present conditions the cost of the nuclear kilowatt hours produced by the plants of the 900-megawatt level, is estimated as 10.4 centimes against 12.6 for the kilowatt hours from coal and 14.1 centimes for the kilowatt hours from oil. On the eve of the oil crisis, we had 4.2 centimes for coal and oil, whereas the cost of the nuclear kilowatt hours was announced as 3.83 centimes.

"We withstood the emergency," they say at Framatome, "but we were frightened." When proposing to EDF the Westinghouse Beaver Valley model, first of the American standard 900-megawatt pressurized water reactor units, the French builder engaged to take the price of the standard unit, and not the real cost of pre-standard production for Fessenheim. This policy, which appeared suicidal, since the State had not yet authorized EDF to program standardized

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nuclear equipment, had discouraged the competitor Ambroise Roux, who in the name of CGE, was offering the General Electric Boiling Water unit. Actually, at the rate of one or two units per year at the "American" prices, Framatome was overextending, and ruining itself. The Yom Kipper War and its energy consequences represented the stroke of luck which by forcing EDF to triple its order of nuclear equipment, turned into coherent management policy the initial Framatome bet.

Simple States of Mind

However for the moment there is still a financial unknown. The 1978 Framatome budget will be the first to indicate the accounting results of the Fessenheim power station, a result which is bound to be negative. The next budget will perhaps indicate how matters stand with the 4 Bugey units (first units of the standard production), balanced to the best possible level, probably still deficit. Starting from 1980-1981, with the accounts from Tricastin and Gravelines, the builders will begin to know whether in terms of MBA [expansion unknown], cash flow or net profit, the stakes were worth the trouble they took.

As far as EDF is concerned, where the barometer for the forecast cost of the kilowatt hour remains within the margin of relatively fair weather, the states of mind are much simpler. Since there will soon be not enough oil in the world to satisfy all the needs, since there will never be enough miners to extract to the maximum the coal reserves, since France will never have enough dollars to raid the world resources of fossile fuels, why ask the stupid question: "If I had to do it all over again, would I do it?"

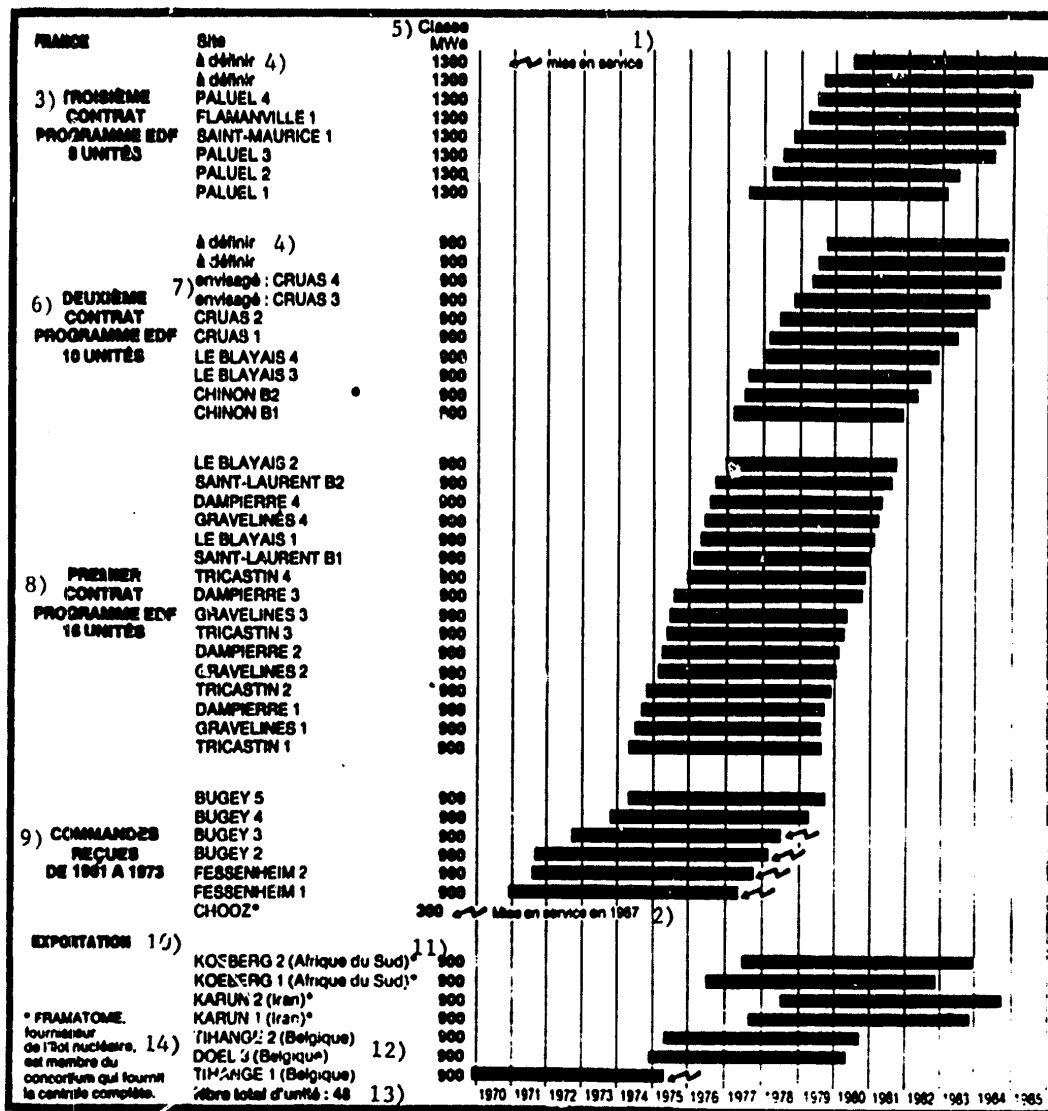


Power stations and sites

The nuclear sites must satisfy very stringent safety requirements, and if possible be located near the sea or a waterway. Hence they are relatively rare

1. gas-graphite line
2. breeder reactors
3. pressurized water reactor line (PWR)

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## Framatome Order Schedule

This table of the orders received by Framatome illustrates the EDF policy: contracts for standardized units, grouped into technical levels, with delivery dates programmed from quarter to quarter. Framatome is also equipped to propose two units per year for export.

[Key on next page]

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[Key to table on previous page:]

1. Put into service 2. Put into service in 1967 3. Third contract EDF  
program 8 units 4. To be defined 5. Class 6. Second contract EDF  
program, 10 units 7. Considered 8. First contract EDF program, 16 units  
9. Orders recieved between 1961 and 1973 10. Export 11. South Africa  
12. Belgium 13. Total number of units 14. Framatome, supplier of the  
nuclear core, is a member of the consortium supplying the complete power  
station

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# FRENCH-INVENTED STEAM GENERATOR SEEN TOO LATE FOR PWR'S

Paris LE MONDE in French 8 Mar 70 p 41

[Article by Xavier Weeger: "No French Steam Generators for the EDF Nuclear Reactors"]

[Text] Do We Really Want to Get Along Without Westinghouse?

The Framatome Company builds French nuclear reactors under license from Westinghouse, an American group. The agreement between the two companies will expire in 1982. In official circles, it is understood that this agreement will probably not be renewed, emphasizing that Framatome, aided by the CEA [Atomic Energy Commission] and EDF [French Electric Co], is now mastering nuclear technology. In short, the American process will be Francized.

However, the recent sad adventure of Georges Trepaud, a small French industrialist, leads one to wonder. He has perfected an original, working steam generator. Use of the process would permit a spectacular Francization of one of the essential components of nuclear reactors. It is feared, however, that this generator will never be used in French power plants, due to a late decision to undertake related research.

Steam generators are very important elements in nuclear reactors. Standing 20 meters high and weighing 300 to 400 metric tons, these huge boilerworks ensure the transfer of heat from the primary circuit to the secondary circuit. The water of the secondary circuit is vaporized, and this vapor then turns the turboalternators, producing electric current.

In the past, the steam generators in the French PWR's [Pressurized-water reactor] have posed some problems. They are subjected to high temperature gradients, and the hundreds of tubes through which flows the pressurized water of the primary circuit have often been victims of extremely severe corrosion phenomena. On top of this, the Westinghouse U-tube generators have the disadvantage of producing a slightly wet vapor.



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Too Late?

Thus, several manufacturers have done research in this field. Babcock & Wilcox perfected a straight-tube generator. In 1972, Georges Trepaud, whose company already builds much boiler equipment for nuclear power plants, envisioned a wavy-tube exchanger. The CEA technicians took an interest in this project which, from the very beginning, gave indications of very interesting thermal performances (notably, an efficiency one percent greater than other steam generators), and a reduced-scale prototype, built and tested at the Nuclear Studies Center at Cadarache, gave remarkable results.

Will this steam generator one day equip French nuclear power plants? Nothing is less certain. EDF, whose research direction sustained the project, informed Trepaud in February that they were giving up building a full-size model of the exchanger, indispensable for precise study of the technical production of such devices. The idea was to demonstrate that this exchanger was economically valid, soon enough so that the Trepaud steam generator could be integrated into the design for the second series of 1300 MW reactors, which will be constructed beginning in the next decade. Introduction of these new steam generators (high performance since two generators would suffice to drain off the reactor's power, as compared to four U-tube steam generators) would entail modification of the primary circuit, and therefore a whole new study of the reactor.

Why this change of plans, Because of the limited industrial capabilities of Trepaud's company, in 1975 EDF had proposed that the model be constructed by Framatome or one of its partners, since the public establishment was ready to finance the operation. It is rumored at EDF that Framatome dragged out the negotiations so long that the engineering management of the public corporation was finally led to say it was "too late."

Framatome states that "there is no conflict" with the CEA or EDF, and that the decision was made by all three partners.

In any case, this "innovation" risks being left in the box. Some see proof in this affair of the lack of enthusiasm manifested by Framatome for Francization of the Westinghouse process. Could they be correct?

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